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CEMENT AND LIME MANUFACTURE

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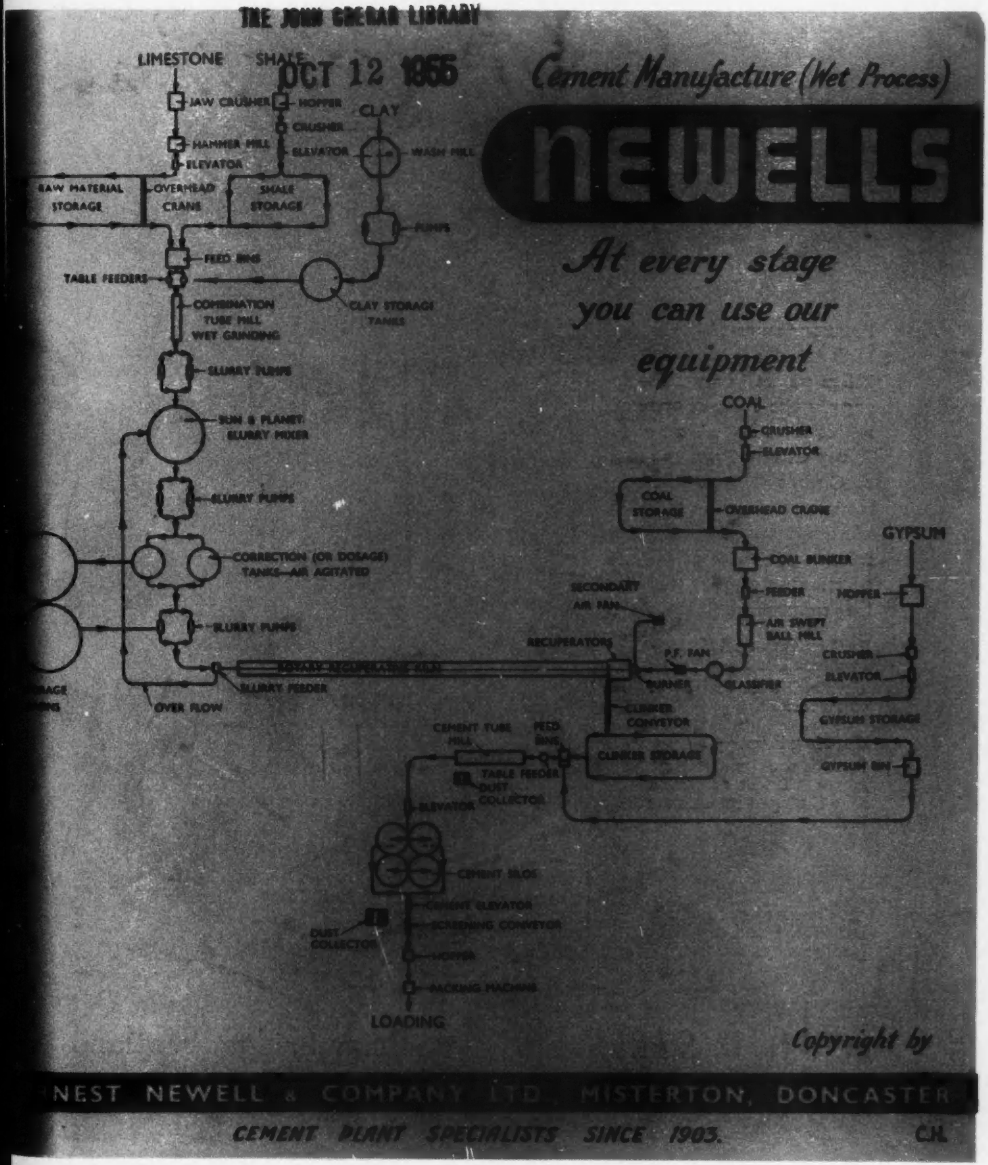

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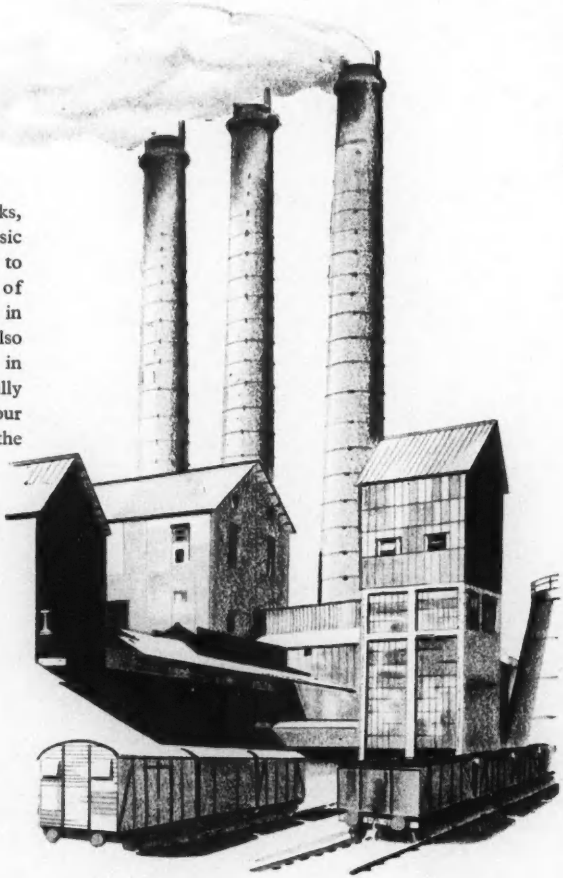

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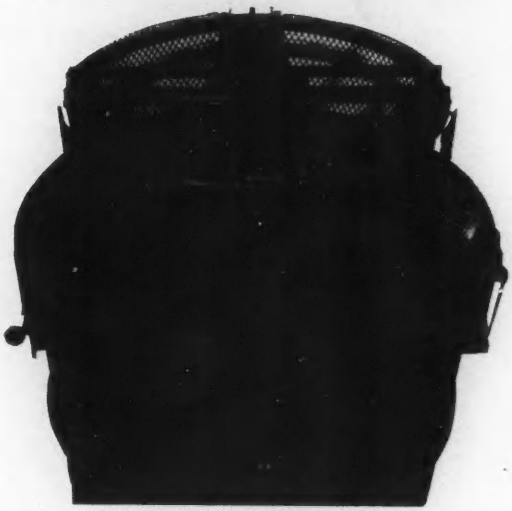

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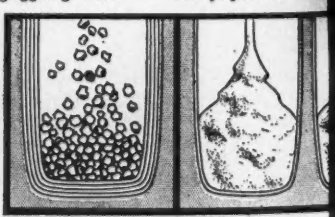

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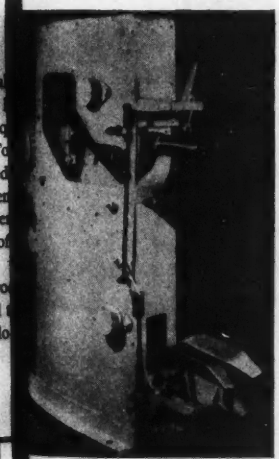

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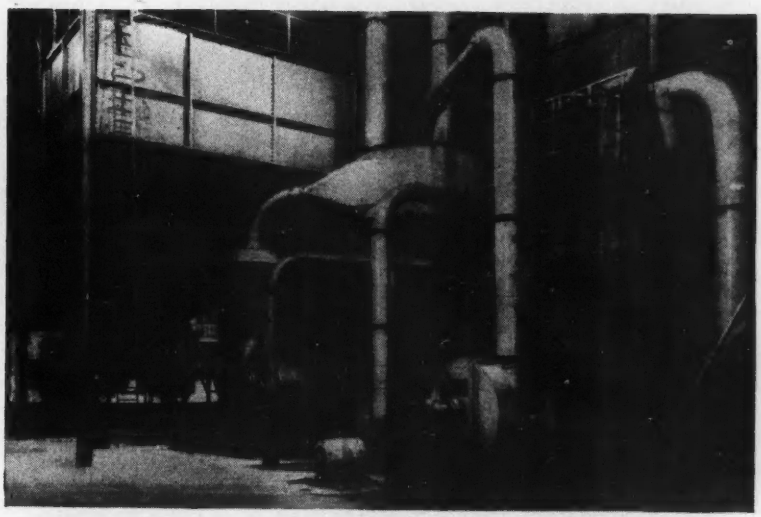

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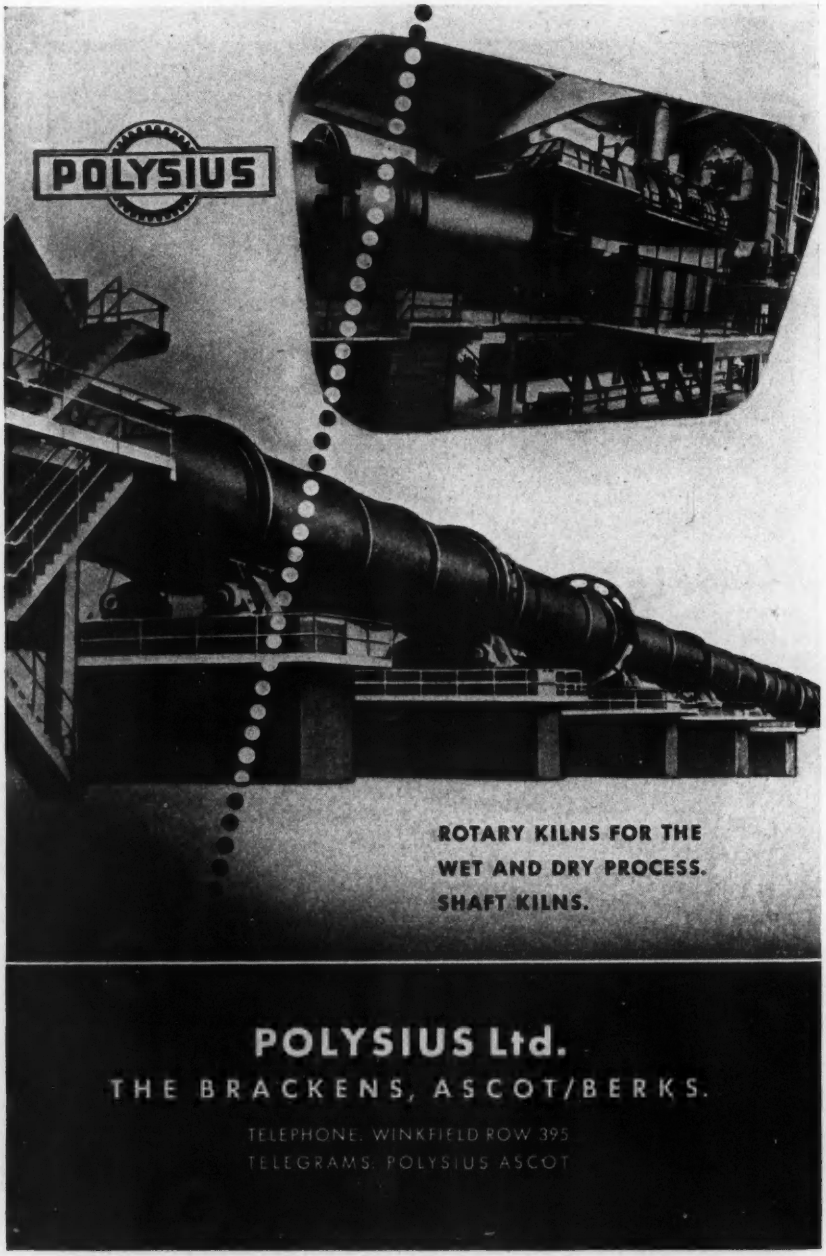
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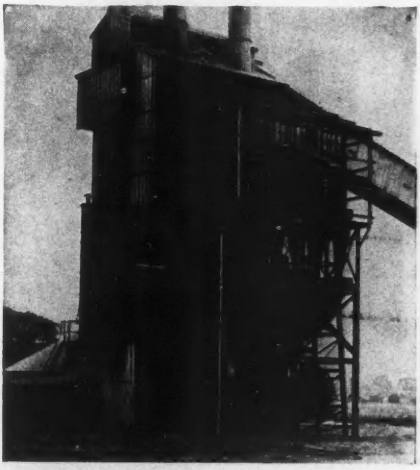

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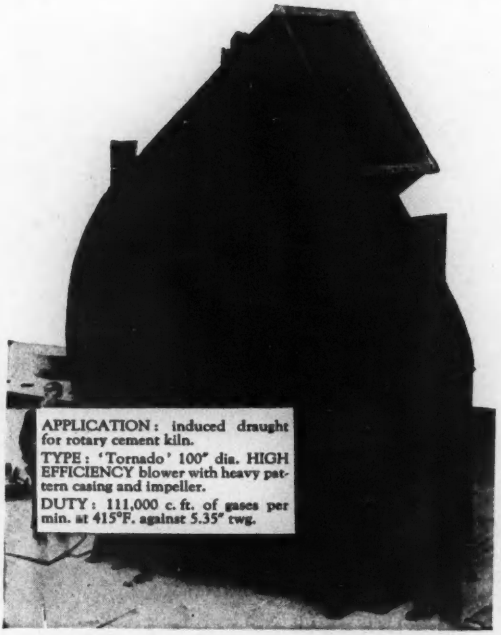
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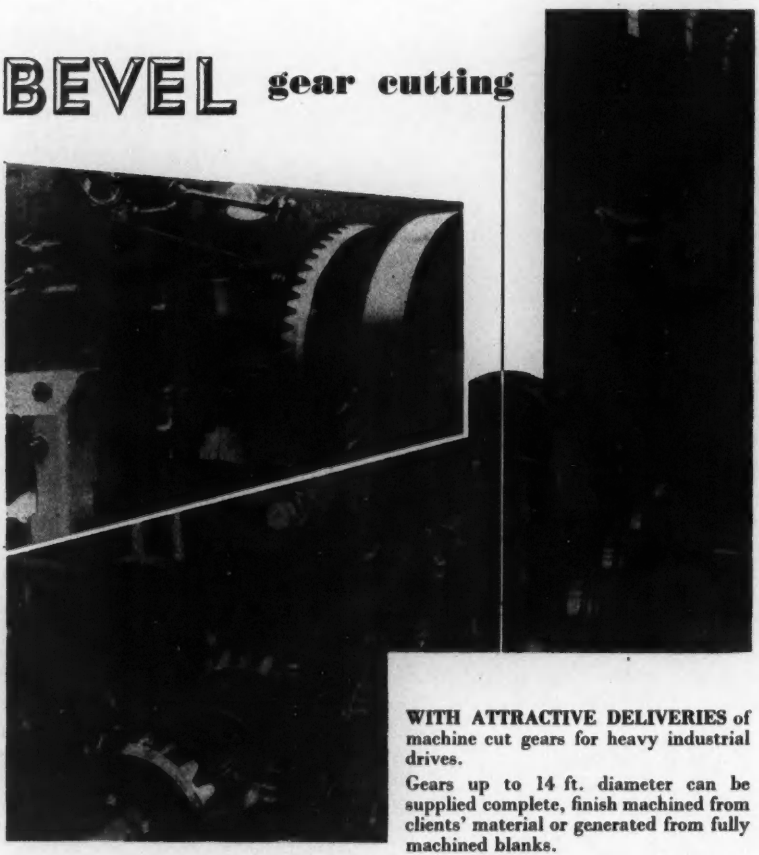

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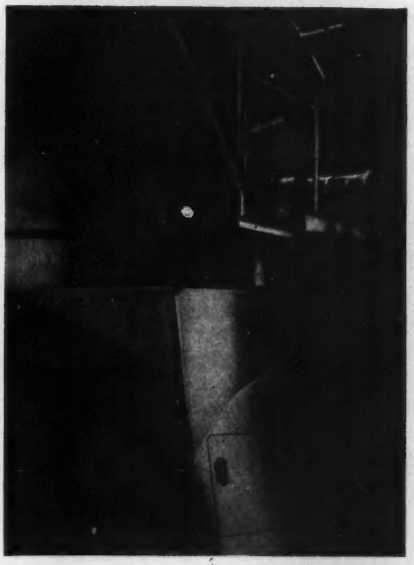

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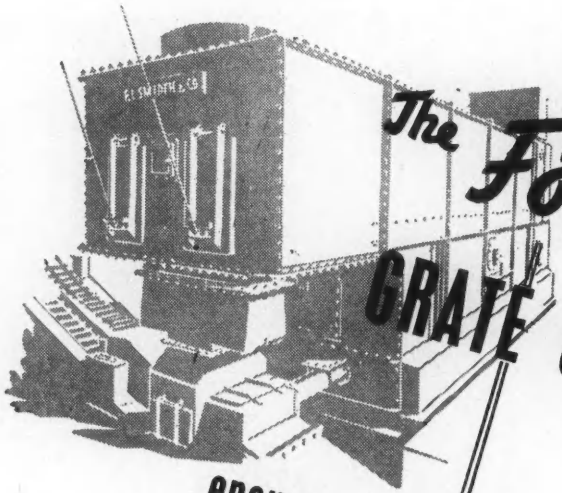

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VOLUME XXVIII. NUMBER 5. SEPTEMBER, 1955

Fifty Years of Progress in Cement Manufacture in Germany.

BY PROFESSOR DR. HANS KÜHL, BERLIN-LICHTERFELDE.

Early Development.

THE standard for Portland cement current in Germany in 1905 had last been revised in 1887, and this required, for an earth-moist mortar of 1 part cement and 3 parts standard sand mixed with about 8 per cent. of water, after hardening for one day in moist air and 27 days in water, a minimum tensile strength of 16 kg. per sq. cm. (227·5 lb. per sq. in.*) and a minimum compressive strength of 160 kg. per sq. cm. (2,275 lb. per sq. in.). The standard of 1909 brought a radical change in the evaluation of the hardening properties of cements by confining the criterion of quality to the compressive strength at 28 days, and the method of curing was changed to one day in moist air, seven days in water, and 21 days in room air. The minimum strength required was 250 kg. per sq. cm. (3,555 lb. per sq. in.), but for cements to be used under water a strength of 200 kg. per sq. cm. (2,844 lb. per sq. in.) was permitted. For short-period site tests a tensile strength of 12 kg. per sq. cm. (170·6 lb. per sq. in.) could be accepted.

Introduction of Rapid-hardening Portland Cement.

About the year 1915, under the guidance of M. Spindel, the Lorüns factory in Austria produced a cement which was notable for its unprecedented high early strength. There was some opposition to this cement by the German cement industry and it was only when the demand for a rapid-hardening cement was intensified by the consumer, and was also supported by specialists such as Dr. R. Grün and Dr. W. Gehler, that the distinction between " ordinary " and high-early strength or rapid-hardening Portland cement was accepted. Other cement makers quickly engaged in the production of rapid-hardening cement. This

* Kilogrammes per square centimetre multiplied by 14.22 throughout.

development called for a revision of the standard, and the strength requirements of the German standard of 1927 are shown in *Table* I. For the first time a test at three days was given, and the strength at 28 days for the high-grade cement was twice that previously required for ordinary cement.

Methods of Testing.

In the year 1939 a radical change was made in the test requirements since it was then evident that the strengths required under the existing test methods were also being attained by many binding materials which did not give these results in practice when used with high proportions of water. As a result a strength test on cement-and-sand mortar with higher water contents was introduced. The test for tensile strength on earth-moist mortars was changed to a test for bending strength on plastic mortars, and the standard sand with an almost uniform size of particle (0·775 mm. to 1·350 mm.) was replaced by a standard sand consisting of 2 parts of coarse sand (similar to the old standard) and 1 part of fine sand with a residue of about 8 per cent. on a sieve with 0·2-mm. meshes and about 70 per cent. on a sieve with 0·09-mm. meshes. The water content of about 8 per cent. was changed to 15 per cent. The compressive strength at 28 days with combined storage was retained as the decisive criterion of quality, although the combined-storage method of testing gave rise to mis-

TABLE I. STANDARD OF 1927
Strengths in kg. per sq. cm. (lb. per sq. in. in brackets)

Type of Cement	Tensile			Compressive			
	3 days	7 days	28 days	3 days	7 days	28 days	
	Water storage	Water storage	Combined storage	Water storage	Water storage	Water storage	C'mbin'd storage
Ordinary	—	18	30	—	180	275	350
	—	(256)	(427)	—	(2560)	(3910)	(4977)
High - grade (rapid-hardening)	25	—	40	250	—	—	500
	(356)	—	(569)	(3555)	—	—	(7110)

TABLE II STANDARD OF 1942
Strengths in kg. per sq. cm. (lb. per sq. in. in brackets)

Type of cement	Bending strength				Compressive strength			
	1 day in air	3 days in water	7 days in water	28 days in water	1 day in air	3 days in water	7 days in water	28 days in water
225	—	—	25	50	—	—	110	225
	—	—	(356)	(711)	—	—	(1564)	(3200)
325	—	30	40	60	—	150	225	325
	—	(427)	(569)	(853)	—	(2133)	(3200)	(4622)
425	25	50	60	70	100	300	360	425
	(356)	(711)	(853)	(995)	(1422)	(4266)	(5119)	(6044)

givings even on its introduction in 1909. Also, the evaluation of cement by compressive strength alone led to a competition amongst manufacturers to produce cement with the highest compressive strength to the detriment of tensile strength to the extent that the ratio between tensile and compressive strengths, which was formerly about 1 : 10, in extreme cases reached 1 : 20.

This was brought to an end in the last revision of the standard in 1942, in which combined storage was abandoned and replaced by water storage. Moreover, measurement of the tensile strength by means of the bending strength is now conceded its proper importance. Simultaneously the distinction between ordinary cement and high-grade or rapid-hardening cement was abandoned, and instead three qualities were introduced with compressive strengths after 28 days' water storage of 225 kg. per sq. cm., 325 kg. per sq. cm., and 425 kg. per sq. cm.; these are known as 225, 325 and 425 cements respectively. The strength requirements of this standard are summarised in *Table* II in which it is noteworthy that for cement of the highest grade a strength requirement after one day is included.

It is seen that the requirement at 28 days of the standard of 1887, which was still current in 1905, of 160 kg. per sq. cm. has been increased to 425 kg. per sq. cm. in spite of the use of almost double the proportion of gauging water. In practice, of course, considerably higher strengths are generally obtained, since the requirements of the standard are minima.

Improved Knowledge of the Chemistry of Cement.

The remarkable improvements in cements is partly a result of the knowledge obtained by scientific investigation and partly of improvements in manufacturing processes. Although H. Le Chatelier recognised in 1887 as a result of microscopic studies that Portland cement clinker comprises a series of different minerals, and although A. E. Törnebohm confirmed this ten years later and conferred on these minerals the still familiar names Alite, Belite, Celite, and Felite, knowledge of the constitution of clinker was then still so sparse that even well-known authorities disagreed on whether the lime was combined with the silicic acid, alumina, and iron, or whether it existed as free lime which entered into reaction with the constituents of the clay (which had been " decomposed " by the burning process) only when the cement was gauged with water.

The magnitude and complexity of the problems to be solved were at that time completely under-rated since within the short period of two years the problem of the constitution of Portland cement was supposed to have been solved, and the hardening processes occurring under different conditions elucidated. After fifty years of intensive research these problems are still unsolved. The true route to the solution of these problems was found only when a start was made on systematic studies of systems containing two, three, four and more of the components constituting cement. The work was undertaken predominantly in America, where the first communication concerning the lime-silica system appeared in 1906. Subsequently, investigators of many countries have participated, among

whom special mention must be made of Dr. F. M. Lea and Mr. T. W. Parker, whose publication on the system lime-silica-alumina-iron oxide in 1934 provided an exhaustive picture of the equilibrium relationships in this subject which is so vital to cement chemistry.

These researches were followed along entirely different paths on both sides of the Atlantic. In America, under the leadership of Mr. R. H. Bogue and Mr. L. A. Dahl, it has become customary to calculate the constitution in terms of the different mineral components, and thus to reckon the lime content by the ratio of tricalcium silicate to dicalcium silicate; investigators in Europe, however, still follow the earlier procedure of forming "moduli," that is ratio numbers between the oxide contents obtained by analysis, a method which was first used by W. Michaelis when he wrote the hydraulic modulus

$$\frac{CaO}{SiO_2 + Al_2O_3 + Fe_2O_3}$$

which was extended by the writer with the introduction of the silica modulus $\frac{SiO_2}{Al_2O_3 + Fe_2O_3}$ and the alumina modulus $\frac{Al_2O_3}{Fe_2O_3}$.

Fifty years ago it was considered that the ratio between alumina and iron oxide, expressed by the alumina modulus, was so unimportant that it could generally be dismissed with a single analytical determination of the sum of these two components. It is now known that the alumina modulus has a special significance in cement chemistry, since it serves to differentiate between ordinary Portland cements rich in alumina and special cements rich in iron oxide. The first representative of the latter type was the "erz," or iron-ore, cement of Michaelis, and this was followed by Ferrari cement with a nearly equal proportions of alumina and iron oxide. These cements had especially valuable properties since they had good strength, low shrinkage, low heat evolution, and good resistance to chemicals, particularly sulphates.

Calculation of the Lime Content.

Progress in knowledge of the constitution of Portland cement brought with it a guiding principle for the manufacturing process, since it became possible to calculate the best lime content for the raw mixture, instead of, as previously, being dependent on trials. The writer pointed the way in 1933 by introducing a standard lime (CaO_{st}) content, which defined the lime content yielding the best hydraulic factor (on the basis of the work of E. Spohn and S. Solacoln) in the region of the sintering temperature between 1,400 deg. C. and 1,450 deg. C.; the formula was

$$CaO_{st} = 2{\cdot}8\ SiO_2 + 1{\cdot}1\ Al_2O_3 + 0{\cdot}7\ Fe_2O_3.$$

This formula was confirmed soon after by Dr. Lea and Mr. Parker, although the British investigators arrived at slightly different coefficients corresponding to the formula

$$CaO_{st} = 2{\cdot}8\ SiO_2 + 1{\cdot}18\ Al_2O_3 + 0{\cdot}65\ Fe_2O_3.$$

This small deviation is insignificant in practice.

Another advance followed from the recognition that an essential requirement of good cement was the highest possible constancy of composition of the raw materials. Cement makers then endeavoured to improve the raw material not by finer grinding but by securing constancy of the desired lime content by increased homogeneity of the material leaving the mill. Although this involved no great difficulty in the wet process, equally good homogeneity of the dry raw mixture remained an unsolved problem so long as it depended on mixing by bucket conveyor. Only on the introduction of fluidization of the raw material by the Polysius Company was homogeneity achieved in the dry process almost as completely as in the slurry of the wet process.

Improvements of Kilns.

The last fifty years have brought advances not only in the preparation of raw mixtures but also in the operation of kilns. This is exemplified in the case of the shaft kiln by the introduction of automatic discharge and feed; not only was the output increased but the quality of the cement was substantially improved, so that the shaft kiln was restored to its competitive position in relation to the rotary kiln, which had entered into the industry at the end of the nineteenth

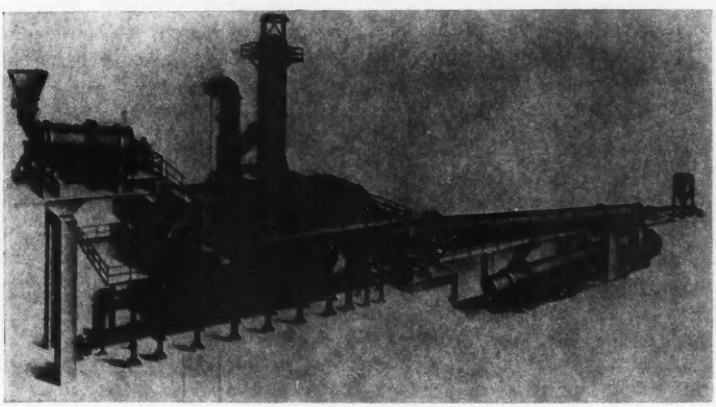


Fig. 1.

century. Further progress in shaft-kiln operation followed from the tendency to use smaller pellets. Fifty years ago shaft kilns were charged with large lumps, while to-day it is recognised that the shaft kiln is best fed with granules such as those prepared in a whirling drum or, more recently still, in a whirling plate machine.

The superior quality of rotary-kiln cements made shaft kilns unpopular, in spite of the fact that at that time the fuel consumption of the rotary kiln was about double that of the shaft kiln. Here also changes were made in the method of operation, by which more intimate heat exchange between the combustion

gases and the charge was obtained. Although in the wet process a chain interchanger was already a definite success, a really effective solution of the problem was achieved only by the insertion of a calcinator or concentrator between the rotary kiln and the stack.

In the dry process the combination of travelling grate and rotary kiln invented by Lellep and developed by the Polysius Company was a decisive advance. A Lepol kiln of modern design with a double gas pass, as shown in *Fig.* 1, has a heat consumption of 850 to 900 kilocalories, which is even more favourable than that of the high-performance shaft kiln. An equally favourable heat consumption was recently achieved by the Humboldt Company by the installation of a carrier-gas heat exchanger. In this method (*Fig.* 2) the dry raw mixture is in suspension in the hot kiln-gases, so that an unusually efficient heat transfer to the charge is

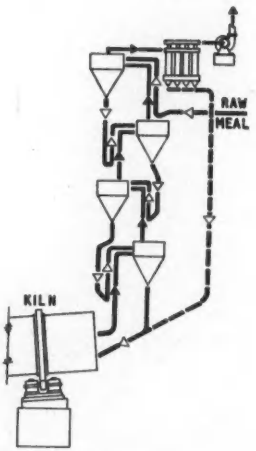


Fig. 2.

effected. Some years ago the shaft and rotary kilns were joined by a third calcining plant, namely the Dwight-Lloyd mechanical sintering grate; in Germany only a few works made use of this process although it offered important advantages, including interrupted firing without the usual damage to refractory linings.

In addition to the proper firing of a correctly prepared and homogeneous raw mixture, a special contribution has been made by the continuous trend towards finer grinding of cement and the resulting increase in strength. The best type of grinding process is still not decided, and the competition is primarily between open-circuit and closed-circuit grinding. Although the advantage of the closed-circuit method is hardly contested in the case of the raw materials, there is still authoritative opinion in favour of direct grinding of cement in, say, a compound mill.

Effect of Shape of Alite Crystals.

Even if this problem is decided, however, the possibilities of further improvement of Portland cement are not exhausted. Quite recently J. Grzymek has shown that for the manufacture of cement with the greatest hardening properties, in addition to the well-known need for correct chemical composition, hard burning, and fine grinding, the volume and shape of the alite crystals are significant. According to Grzymek many small alite crystals, especially if they are long and needle-shaped, lead to quicker early hardening than larger rounded crystals in cement of the same composition. The means of producing this type of alite crystal is so far unsolved.

Blastfurnace Cements.

Although as long ago as 1774 Loriot made a mortar of blastfurnace slag and slaked lime, commercial manufacture of an hydraulic binding material from blastfurnace slag did not take place until almost a hundred years later. The new industry met with opposition from the Portland cement industry; on the one hand it was denied that slag had any cementing properties and on the other hand there was opposition to the use of the term Portland cement to describe cement containing slag. This discussion continued until it became known that only certain high-lime and rapidly cooled slags had hydraulic properties, and another name was introduced for the material manufactured from blastfurnace slag.

The addition of slag to Portland cement was restricted to a maximum of 30 per cent. and the product was called Eisenportland (iron-Portland) cement. At the beginning of this century H. Passow showed that many blastfurnace slags required only a small addition of an alkaline activator in order to arouse latent hydraulic powers of cementing. This led to the manufacture of cements which contained far more slag than the Eisenportland cement; these were called Hochofen, or blastfurnace, cements. This contrast between iron-Portland and blastfurnace cement has been retained in Germany, although the border-line proportion of 30 to 70 per cent. permitted by the German standard is as arbitrary as it is historical. The result is that to-day both types of cement are often referred to by the common name Hütten (metallurgical) cement. This is quite logical, since the two cements, one iron-Portland containing 29 per cent. of slag and the other metallurgical containing 31 per cent. of slag obviously would not have any perceptible difference in technical properties.

After experience and tests had shown that with correct manufacture the three types of cement, namely Portland, iron-Portland, and blastfurnace, were of equal value, a single standard was introduced in Germany in 1916 for all three binding materials, so that they are often referred to by the common name "Standard" cement.

Sulphate-metallurgical Cements.

To these three cements has been added more recently a fourth standard cement the sulphate-metallurgical cement or super-sulphated cement; this consists essentially of blastfurnace slag rich in alumina together with gypsum (12 to 16 per cent.) and a small proportion of alkaline activator (usually about 1 to 2 per cent. of

lime or 3 to 5 per cent. of Portland cement clinker). This cement, originally known as gypsum-slag cement, also has a long history, since it was discovered by the writer as long ago as 1909; its introduction met with great difficulties because disastrous experiences of the action of gypsum in Portland cement caused some people to doubt whether a binding material with such a high gypsum content could be safe even though it had exceptionally high resistance to sulphates. Only when the work of L. Blondiau had placed the advantages of this cement in a clear light was sulphate-metallurgical cement made commercially in Belgium, and only towards the end of the last war was manufacture of this cement undertaken in Germany. This cement combines many valuable properties. Investigations by F. Köberich and W. Kramer have shown that, by using basic slag rich in alumina, the early hardening of sulphate-metallurgical cement approaches that of high-alumina cement, and that, with careful adjustment of the alumina content of the slag and the proportions of slag to gypsum, a strength not inferior to that of the best Portland cements can be obtained.

Another important property of sulphate-metallurgical cement is its low heat evolution during hardening, which makes it suitable for mass constructions such as dams. The American authorities could have spared themselves the search for a " low-heat cement " if sulphate-metallurgical cement had been made in America, for the small heat evolved is accompanied by small shrinkage, which makes the use of these cements in mass concrete particularly suitable.

Finally, reference must be made to the high resistance of sulphate-metallurgical cement to chemical attack, especially against sulphates. Investigations, which have already extended over nearly two decades, have shown that test specimens of sulphate-metallurgical cement on immersion in sea-water and other sulphate solutions suffer little loss in strength. This combination of valuable properties has caused leading authorities of the German steel industry to give increasing attention to the composition of their slags, thus responding to the wishes of leading men of the cement industry such as Passow, Guttmann, Grün, and Keil; the metallurgists no longer regard the slag as an unwanted by-product.

The past fifty years have seen outstanding progress in all spheres of cement production. This progress will continue, and we may in the future expect further improvement.

Proposed New Cement Works in The Philippines.

It is reported that a new cement works with a capacity of about 400 tons a day is to be erected in the province of Bulacan, Philippines at a cost of 10,000,000 dollars.

The Cement Industry in Spain.

A well-produced volume of 250 pages has been issued by Agrupacion de Fabricantes de Cemento de España to commemorate the fiftieth year since Portland cement was first made in Spain. In addition to much information on the development of the industry, information and illustrations are given relating to all the cement works now in production in Spain.

Burning Cement In Air-Suspension.

An investigation of a new type of cement burning installation at the pilot-plant stage is described by E. I. Hodorov and W. M. Kosareva in the Russian journal "Tsement" for January 1955. Considerable advantages are claimed for the installation, particularly its high thermal efficiency and very large increase in output compared with ordinary kilns.

The installation consists of a short rotary kiln and a vertical air-suspension pre-dryer and calcinator (*Fig.* 1). The hot exit gases from the kiln are drawn through a number of beds of granulated raw meal supported by grates. The velocity of the gases is such that the granules of the raw meal are subjected to continuous agitation, resembling that occurring in boiling liquids. The comparatively small size of the granules results in a large surface area per unit volume being exposed to the gases. This gives a high degree of heat transfer and only 14 to 15 minutes are required for the pre-heating, drying, and calcining of the raw

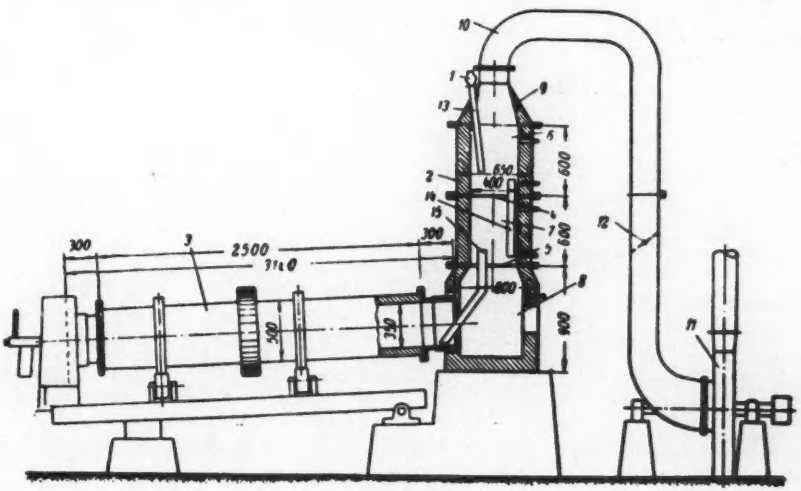


Fig. 1.

meal. The final burning of the clinker is done in the kiln. The installation is fed through pipe 1 (in *Fig.* 1) which reaches nearly to the bottom of the cylindrical chamber (6). Here the granulated feed is pre-dried and passed through another pipe (14) into compartment (7) where the material is calcined prior to being passed into the kiln via pipe (15). Chamber (2) has an internal diameter of 650 mm. and is divided by grates (4 and 5) to form compartments (6 and 7) each 6 m. high. Grate (4) is of normal steel and grate (5) is of heat-resisting steel. Both grates are 4 mm. thick and have perforations of 4 mm. diameter.

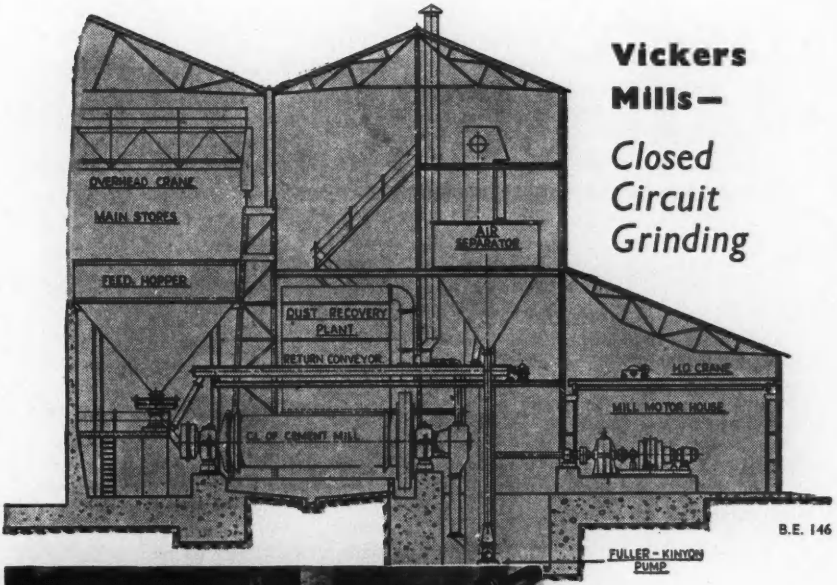
The rotary kiln is 31 m. long by 5 m. diameter and is placed on a special type of bed which permits a large variation in the inclination of the kiln. The kiln is rotated at 0·59 to 1·76 r.p.m. The installation is lined with chamotte bricks 125 mm. thick in chamber (2), and chrome-magnesite bricks are used for lining the kiln, which is fired by oil.

The speed at which the gases are drawn through the kiln is just sufficient to maintain the granules in chamber (2) in a state of suspension in the gas. The arrangement of pipes (14) and (15) is such that the bottom end of pipe (14) is 60 mm. above the level of grate (5); in this way the layer of granules just below the pipe forms a barrier which prevents the gases flowing up the pipe and the rate at which the granulated material enters chamber (7) is equal to that at which it is delivered to chamber (6). Pipe (15) is full all the time. The rate of feed depends partly on the distance between the lower end of pipe (15) and the neck of the kiln and partly on the speed of the kiln.

Data obtained in a series of tests are given in *Table* 1. The raw meal consisted of a mixture of limestone and clay, previously ground to 4 to 10 per cent.

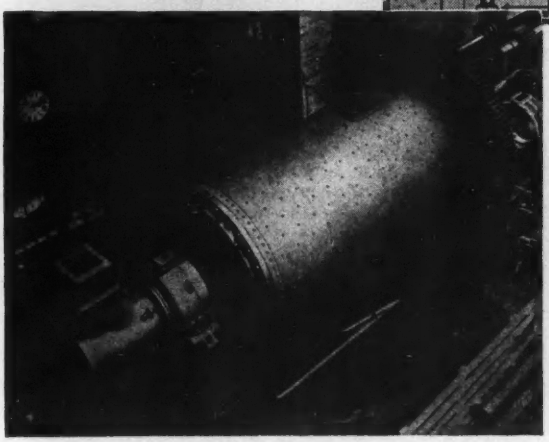
TABLE I
TEST RESULTS

	Test Number				
	1	2	3	4	5
Fuel consumption, kg. per hour	23·00	21·30	26·00	19·70	18·70
Raw meal feed, kg. per hour	97·4	83·4	82·5	77·0	106·5
Ignition loss, per cent.	34·91	34·26	34·26	34·26	35·22
Bulk weight of granules, kg. per litre	1·04	1·06	1·06	1·21	1·22
Feed temperature, chamber I, deg. C.	552	674	595	640	527
Ignition loss in chamber I, per cent.	30·47	29·39	31·88	32·23	28·10
Bulk weight of granules in chamber I in kg. per litre	0·96	1·03	0·977	1·02	1·00
Temperature of the material in chamber II, deg. C.	847	780	813	800	897
Ignition loss in chamber II, per cent.	6·62	2·02	5·18	2·90	1·50
Free lime in chamber II, per cent.	34·00	37·88	35·87	35·14	—
Bulk weight in chamber II, kg. per litre	0·76	0·82	0·86	0·81	0·84
Free lime in clinker, per cent.	1·83	0·77	1·02	0·22	—
Gas temperature, deg. C.					
In the burning zone,	—	—	1460	1508	1540
Back end of the kiln	1052	1107	1005	1007	1125
Chamber II	450	533	470	445	483
Chamber I	450	533	470	445	483
Flue gas	—	208	226	244	231
Suction (mm. water gauge):					
In chamber II	88	87	105	115	110
In chamber I	212	202	202	235	200
Before the fan	—	208	226	244	231
Dust emission, per cent.	—	8·35	5·75	8·50	—
Gas velocity, m./per second					
In chamber I	2·60	2·10	3·63	2·24	2·52
In chamber II	2·74	2·62	3·18	2·34	3·04
Time of travel in minutes					
Through chamber I	8·90	10·2	9·6	10·8	7·6
Through chamber II	8·40	14·2	8·9	9·8	7·14
Output, in kg. per hour	—	40·60	53·50	39·40	58·80



Vickers Mills—

Closed Circuit Grinding



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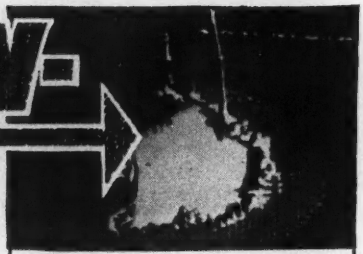

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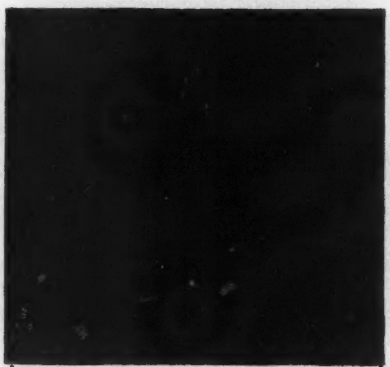

It is not only in conditions like these that mildew spores breed and multiply, wrecking havoc with a belt. Unless inhibited during manufacture, belt life may be short on any installation.

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residue on a 0·0085 sieve (Russian standard). The average size of the granules was from 3 to 4 mm. which remained unchanged during the passage of the material through the installation and corresponded to the size of the clinker produced. Heat transfer between the hot gases and the granulated material was very effective and took place uniformly. The material flowed freely through the stages of the process and entered the kiln at about 900 deg. C., that is in a fully-calcined condition. The function of the kiln is thus limited to the final burning of the clinker, hence a kiln with a length to internal diameter ratio of about 8 is suitable for the purpose. Among the advantages claimed for this method of burning clinker are high output, high quality of clinker, high thermal efficiency, and some improvement in ease of grinding the clinker. The loss of dust does not exceed 10 per cent. The output of the fan was 1500 cu. m. per hour, giving the highest obtainable suction of 230 mm. water-gauge. This was the only factor limiting the output of clinker, as the rather small fan output was insufficient for any increase in the number of suspension chambers. No definite conclusion could be drawn

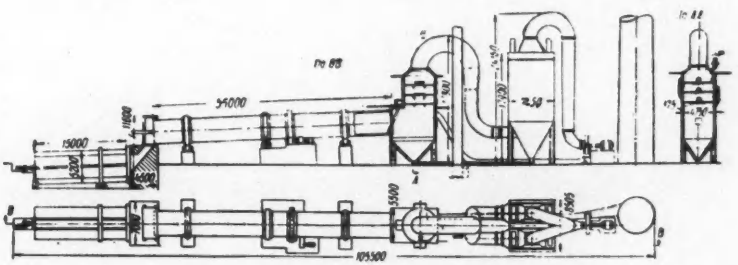

Fig. 2.

regarding the thermal efficiency of the installation, as heat losses in pilot plants are usually very much higher than those in similar production units.

As a result of these tests it is proposed to build two larger installations with capacities of 13 and 45 tons of clinker per hour. Assuming 10 per cent. moisture content of the granulated feed, a 10 per cent. loss in the form of dust, and a temperature of 200 deg. C. in the exit gas, it is expected to get heat efficiency of about 1,000 cal. per kg. of clinker. The installation with a capacity of 13 tons per hour is to be equipped with a 200 kW. suction fan capable of a maximum output of 60,000 cu. m. per hour and 900-mm. water-gauge suction at a gas temperature of 190 deg. C. The installation with a capacity of 45 tons per hour will require a 780-kW. fan with an output of 210,000 cu. m. per hour, and a suction of 1,000 mm. water-gauge, at a gas temperature of 150 deg. C. The diameter of the vertical chamber will be 2·5 metres for the installation with a capacity of 13 tons per hour and 5 metres for the installation with a capacity of 45 tons per hour. The specific output of the chamber should be 2500 kg. per square metre of the cross-sectional area. The suction developed should be sufficient to lift the suspended columns of

raw meal to a height of 900 mm. after allowing for any loss of pressure in the pipes. To make sure that the intended exit-gas temperature is reached, the main chamber will be subdivided into three compartments each 300 mm. high. The dimensions of the chamber are chosen so as to correspond to the required degree of preheating and calcination at 900 deg. C.

The kiln for the installation with a capacity of 13 tons per hour will be 3 m. diameter, and for the installation with a capacity of 45 tons per hour this will be increased to 5 m. The lengths of the kilns are 30 and 55 m. respectively. The general arrangement of the larger installation is given in *Fig.* 2. Plans are also made for a grate-cooling system should this become necessary. In the design of this unit care was taken to arrange the air and feed pipes so as to permit easy access for maintenance purposes. Dust will be recovered by an electrostatic filter and re-introduced for reburning. The general principle of the design of the installation is such that it can be easily adapted for use in other industries, for example, lime, gypsum, superphosphate.

High-alumina Cement.

In the Report of the Building Research Station for the year 1954 (H.M. Stationery Office. Price 4*s*.) it is stated that an investigation is being made into the decrease in strength of high-alumina cement in one of its applications in the electrical industry. This cement suffers a marked loss in strength if maintained in a humid atmosphere at temperatures above normal and the investigation has been directed to a study of the mineralogical changes associated with this loss in strength. It has been established that the first compound formed on hydration of high-alumina cement is $CaO.Al_2O_3.10H_2O$, and that it is this substance which gives the high early strength. The compound is not stable in warm, moist conditions and undergoes a chemical change as follows:

$$3(CaO.Al_2O_3.10H_2O) = 3CaO.Al_2O_3.6H_2O + 2Al_2O_3.3H_2O + 6H_2O.$$

This reaction is always associated with the decrease in strength of set high-alumina cement cured under warm conditions. Attempts have been made to stabilize the $CaO.Al_2O_3.10H_2O$ by chemical additions, but so far without success.

It is suggested that it might be possible to modify the composition of the cement to produce a more stable hydrated compound which would contribute equally well to the early strength of the cement.

Proposed New Cement Works in Peru.

Senor Enrique Mejia Tupayachi, of the firm Fabrica de Tejidos de Lana Marangani S.A., of A.Miro Quesada 221, Lima, proposes to build a cement works near Cuzco.

Proposed New Cement Works in India.

The Indian Ministry of Commerce and Industry has granted licences for the erection of a cement works at Hind by the Hindustan Investment Corporation (8 Royal Exchange Place, Calcutta), and at Vindya Pradesh, Satna, by Messrs. Birla Brothers, Ltd., of the same address.

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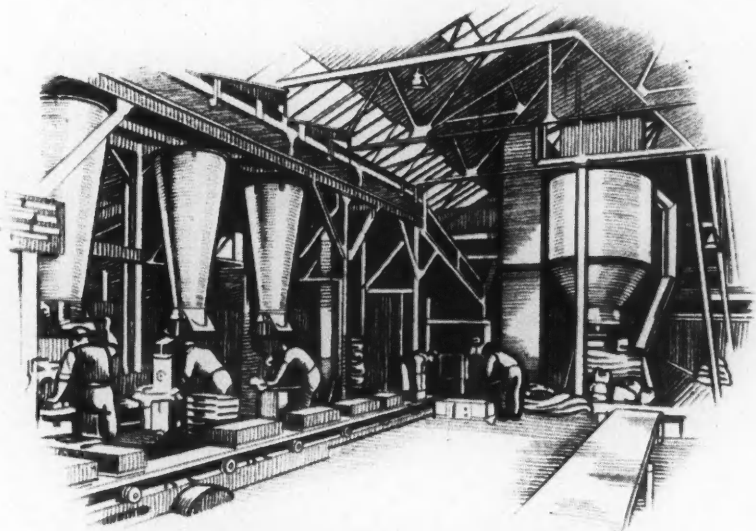

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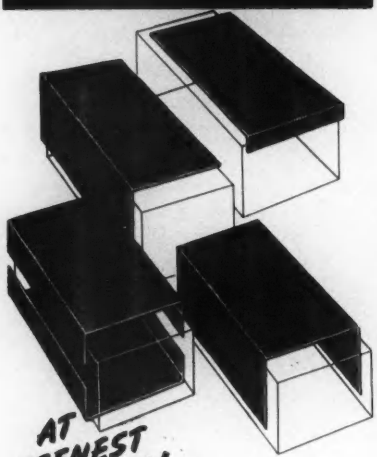

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B.1	62-64%	36
B.	57-59%	36
D.	39-42%	33

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Prevention Of Accidents.

The report for the year 1954 of the Accident Prevention Advisory Committee of the Cement Makers' Federation shows a steady improvement in the accident rate. The number of accidents was 550 in 1950, 544 in 1951, 430 in 1952, 433 in 1953, and 424 in 1954. A graph illustrating the number of accidents each month during the past three years shows that more accidents occurred in October than in any other month, and the Committee suggests that the companies try to ascertain the reason. The departments where most accidents occurred were Filling and Loading (17·78 per cent. of the total) and Maintenance (16.63 per cent. of the total). Of the causes, 20·79 per cent. of the total accidents were due to falls and 18·48 per cent. were due to objects falling, and accidents to men stepping on or striking against or getting caught between objects were 18·01 per cent. The lesson is that accidents are caused more often by human error than by machinery. Accidents caused by machinery were only 5·42 per cent. of the total.

Injuries to eyes from cement and dust were fewer than in the previous year. Men engaged in filling and loading suffered nine out of the twenty eye injuries in the industry.

Apart from sprains, out of a total of 424 lost-time accidents 79 involved feet. Most of the accidents were caused by objects falling—such as a brick, a steel ball, a loading board, a pipe, a pick, a barrow, a stool, a sleeper, a 7-lb. hammer, a steel plate, lumps of coal, and even a boiler funnel. In some cases feet got caught between objects or struck against them. In other cases men were injured when stepping on objects, and one or two injuries were caused by clinker or lime burns. Injuries ranged from minor bruises to fractured toes, and time lost varied from one day to several weeks. The Committee recommends that more encouragement be given to the use of safety boots; at least half of the accidents caused by objects falling could have been avoided, or their consequences lessened, if safety boots had been worn.

Two fatal accidents occurred during the year, compared with four in the previous year. In one case the driver of a motor-cycle on a works road hit a stationary lorry, and in the other case a man was found fatally injured at the base of a 100-ft. chalk face. It is presumed that he fell from the top ledge on which there were topsoil conveyor-belts.

Attention is drawn to the advantages of non-sticking waterproof suits made of plastic-faced material, to the popularity in some works of the "donkey" jacket, to heavy-duty gloves suitable for quarry drillers, a drying powder for the insides of Wellington boots, and safety helmets of aluminium, fibre-glass, plastic, and other materials.

It is noted that one company called in all its safety belts, fitted them with new lines, and colour-banded them for purposes of identification; the colour is

changed at each subsequent inspection. The Committee suggests that this idea could with advantage be adopted by other companies.

During the year 1954 there were no accidents at the Barnstone, Norman, and Sundon works of the " Blue Circle " group or at the Gartsherrie works of the Bairds & Scottish Steel Co., and a trophy has been awarded to each of these four works.

Extension of Cement Works in Jamaica.

It is proposed that the capacity of the works of the Caribbean Cement Co., Ltd., be increased from 100,090 to 120,000 tons a year at a cost of £145,000.

Cement Industry in Norway.

It is expected that the production of cement in Norway will be increased by 200,000 tons by the end of this year, thus increasing the total production to nearly one million tons, which is almost sufficient for Norway's requirements.

Brazilian Cement Imports.

Communication No. 40 issued by the Foreign Trade Department of Brazil deals with the importation of Portland cement and with the composition and method of describing the quality of cement.

Proposed New Cement Works in Ecuador.

The Government of Ecuador is considering the erection of a cement works at Guapan. Production is expected to start in November at the plant now being erected at San Juan near Riobamba.

Reducing Cement Dust.

British patent No. 683,065 granted to the Yorkshire Dyeware & Chemical Co., Ltd., states that the tendency of powders, for example, cements, to form dust clouds is reduced by intimately mixing with the powder a liquid aliphatic alcohol of 7 or more carbon atoms per molecule in such an amount that the powder remains free flowing. The use of 0·1 to 2 per cent. of alcohol by weight is mentioned, generally 1 per cent. is said to be satisfactory. The alcohol may be mixed by tumbling with the powder or added in a volatile solvent, for example, ether or carbon tetrachloride. Oleyl alcohol is specified. In an example Portland cement is mixed with lauryl alcohol.

[Publication of British Patent Specifications has been delayed due to the war.]

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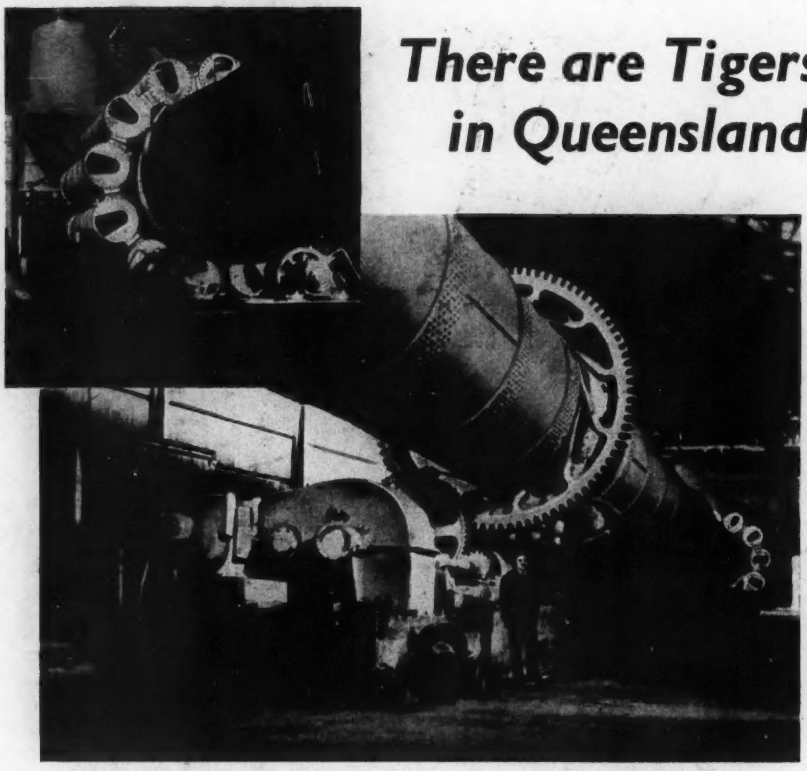

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